

1 CLAIMS:

2 1. A low k interlevel dielectric layer fabrication method
3 comprising:

4 providing a substrate having integrated circuitry at least partially
5 formed thereon;

6 forming an oxide comprising interlevel dielectric layer comprising
7 carbon and having a dielectric constant no greater than 3.5 over said
8 substrate; and

9 after forming the carbon comprising dielectric layer, exposing it to
10 a plasma comprising oxygen effective to reduce the dielectric constant
11 to below what it was prior to said exposing.

12 2. The method of claim 1 wherein the exposing is effective to
13 increase stability of the dielectric constant to variation from what it was
14 prior to the exposing.

16 3. The method of claim 1 comprising exposing the carbon
17 comprising dielectric layer to a plasma comprising oxygen effective to
18 reduce the dielectric constant to at least 15% below what it was prior
19 to said exposing.

21 4. The method of claim 1 wherein the oxygen comprising
22 plasma is at least in part derived from O₂.

1 5. The method of claim 1 wherein the oxygen comprising
2 plasma is at least in part derived from O₃.

3
4 6. The method of claim 1 wherein the oxygen comprising
5 plasma is at least in part derived from N₂O.

6
7 7. The method of claim 1 wherein the oxygen comprising
8 plasma is at least in part derived from NO_x.

9
10 8. The method of claim 1 wherein the dielectric layer
11 comprising carbon is formed by chemical vapor deposition in a chamber,
12 the exposing occurring within the chamber without removing the
13 substrate from the chamber between the forming and the exposing.

14
15 9. The method of claim 8 wherein the chemical vapor
16 deposition is plasma enhanced.

17
18 10. The method of claim 1 wherein the temperature during the
19 exposing is always less than or equal to 550°C.

20
21 11. The method of claim 1 wherein the plasma exposing is
22 ineffective to appreciably etch the interlevel dielectric layer.

1 12. The method of claim 1 wherein the dielectric layer subjected
2 to the exposing comprises silicon bonded to organic material.

3
4 13. The method of claim 1 wherein the dielectric layer subjected
5 to the exposing comprises silicon atoms bonded to both organic material
6 and nitrogen.

7
8 14. The method of claim 1 wherein the carbon is present as a
9 CH₃ group.

10
11 15. The method of claim 1 wherein the dielectric layer subjected
12 to the exposing comprises (CH₃)_xSiO_y.

13
14 16. The method of claim 1 wherein the dielectric layer subjected
15 to the exposing comprises (CH₃)_xSiO_y which remains as (CH₃)_xSiO_y
16 after the exposing.

17
18 17. The method of claim 1 wherein the dielectric layer subjected
19 to the exposing consists essentially of (CH₃)_xSiO_y.

1 18. The method of claim 1 wherein the dielectric layer subjected
2 to the exposing comprises $(CH_3)_xSiO_y$ which remains as $(CH_3)_xSiO_y$
3 after the exposing, and wherein the exposing comprises at least 20
4 seconds.

5
6 19. The method of claim 1 wherein a whole of the dielectric
7 layer subjected to the exposing is not transformed from one base
8 chemistry to another by the exposing.

9
10 20. The method of claim 1 wherein the dielectric layer subjected
11 to the exposing comprises silicon bonded to organic material, a whole
12 of the dielectric layer subjected to the exposing is not transformed from
13 one base chemistry to another by the exposing, and the exposing
14 comprises at least 20 seconds.

15
16 21. The method of claim 1 wherein the dielectric layer subjected
17 to the exposing comprises silicon bonded to organic material, a whole
18 of the dielectric layer subjected to the exposing is not transformed from
19 one base chemistry to another by the exposing, and the exposing
20 comprises at least 40 seconds.

1 22. The method of claim 1 wherein the dielectric layer subjected
2 to the exposing comprises silicon bonded to organic material, a whole
3 of the dielectric layer subjected to the exposing is not transformed from
4 one base chemistry to another by the exposing, and the exposing
5 comprises at least 60 seconds.

6

7 23. The method of claim 1 wherein the dielectric layer subjected
8 to the exposing comprises silicon bonded to organic material, a whole
9 of the dielectric layer subjected to the exposing is not transformed from
10 one base chemistry to another by the exposing, and the exposing
11 comprises at least 80 seconds. X

12

13 24. The method of claim 1 wherein the dielectric layer subjected
14 to the exposing comprises silicon bonded to organic material, a whole
15 of the dielectric layer subjected to the exposing is not transformed from
16 one base chemistry to another by the exposing, and the exposing
17 comprises at least 100 seconds.

18

19 25. The method of claim 1 wherein the majority of the carbon
20 present in the dielectric layer is in the form of methyl groups, and
21 wherein the methyl groups comprise from 10% to about 50% of the
22 dielectric layer (mole percent) before and after the exposing.

1 26. A low k interlevel dielectric layer fabrication method
2 comprising:

3 providing a substrate having integrated circuitry at least partially
4 formed thereon;

5 forming a nitride comprising interlevel dielectric layer comprising
6 carbon and having a dielectric constant no greater than 8.0 over said
7 substrate; and

8 after forming the carbon comprising dielectric layer, exposing it to
9 a plasma comprising nitrogen effective to reduce the dielectric constant
10 to below what it was prior to said exposing.

11 *D* 27. The method of claim 26 wherein the nitrogen comprising
12 plasma is at least in part derived from N₂.

14 *B* 28. The method of claim 26 wherein the nitrogen comprising
15 plasma is at least in part derived from NH₃.

17 *H* 29. The method of claim 26 wherein the nitrogen comprising
18 plasma is at least in part derived from N₂H₄.

20 *S* 30. The method of claim 26 wherein the nitrogen comprising
21 plasma is at least in part derived from N₂O.

~~31. The method of claim 26 wherein the nitrogen comprising plasma is at least in part derived from NO_x.~~

~~32. The method of claim 26 wherein the dielectric layer comprising carbon is formed by chemical vapor deposition in a chamber, the exposing occurring within the chamber without removing the substrate from the chamber between the forming and the exposing.~~

~~33.~~ The method of claim ~~26~~ wherein the carbon is present as
a CH_3 group.

1 34. A low k interlevel dielectric layer fabrication method
2 comprising:

3 providing a substrate having integrated circuitry at least partially
4 formed thereon;

5 in a chamber, plasma enhanced chemical vapor depositing an
6 interlevel dielectric layer comprising carbon and having a dielectric
7 constant no greater than 3.5 over said substrate at subatmospheric
8 pressure; and

9 after forming the carbon comprising dielectric layer, exposing it to
10 a plasma comprising oxygen at a subatmospheric pressure effective to
11 reduce the dielectric constant by at least 10% below what it was prior
12 to said exposing, the exposing occurring without removing the substrate
13 from the chamber between the depositing and the exposing, and
14 pressure within the chamber being maintained at subatmospheric between
15 the depositing and the exposing.

16
17 35. The method of claim 34 wherein at least two precursors are
18 fed to the chamber during the depositing, one of the precursors
19 comprising oxygen, the exposing comprising substantially ceasing feeding
20 another of the precursors while feeding the one, and maintaining plasma
21 conditions within the chamber from the depositing through the exposing.

1 36. The method of claim 34 wherein the plasma enhanced
2 chemical vapor depositing comprises feeding a methyl silane to the
3 chamber.

4

5 37. The method of claim 34 wherein the dielectric layer
6 comprises silicon bonded to organic material.

7

8 38. The method of claim 34 wherein the dielectric layer
9 comprises silicon atoms bonded to both organic material and nitrogen.
10 X

11

12 39. The method of claim 34 wherein the oxygen comprising
13 plasma is at least in part derived from O₂.

14

15 40. The method of claim 34 wherein the oxygen comprising
16 plasma is at least in part derived from O₃.

17

18 41. The method of claim 34 wherein the oxygen comprising
19 plasma is at least in part derived from N₂O.

20

21 42. The method of claim 34 wherein the oxygen comprising
22 plasma is at least in part derived from NO_x.

1 43. The method of claim 34 wherein the dielectric layer
2 subjected to the exposing comprises $(CH_3)_xSiO_y$.

3
4 44. The method of claim 34 wherein the dielectric layer
5 subjected to the exposing comprises $(CH_3)_xSiO_y$ which remains as
6 $(CH_3)_xSiO_y$ after the exposing.

7
8 45. The method of claim 34 wherein the dielectric layer
9 subjected to the exposing ~~consists essentially of~~ $(CH_3)_xSiO_y$.

10
11 46. The method of claim 34 wherein the dielectric layer
12 subjected to the exposing comprises $(CH_3)_xSiO_y$ which remains as
13 $(CH_3)_xSiO_y$ after the exposing, and wherein the exposing comprises at
14 least 20 seconds.

15
16 47. The method of claim 34 wherein a whole of the dielectric
17 layer subjected to the exposing is not transformed from one base
18 chemistry to another by the exposing.

1 48. The method of claim 34 wherein the dielectric layer
2 subjected to the exposing comprises silicon bonded to organic material,
3 a whole of the dielectric layer subjected to the exposing is not
4 transformed from one base chemistry to another by the exposing, and
5 the exposing comprises at least 20 seconds.

6

7 49. The method of claim 34 wherein the dielectric layer
8 subjected to the exposing comprises silicon bonded to organic material,
9 a whole of the dielectric layer subjected to the exposing is not
10 transformed from one base chemistry to another by the exposing, and
11 the exposing comprises at least 40 seconds.

12

13 50. The method of claim 34 wherein the dielectric layer
14 subjected to the exposing comprises silicon bonded to organic material,
15 a whole of the dielectric layer subjected to the exposing is not
16 transformed from one base chemistry to another by the exposing, and
17 the exposing comprises at least 60 seconds.

18

19 51. The method of claim 34 wherein the majority of the carbon
20 present in the dielectric layer is in the form of methyl groups, and
21 wherein the methyl groups comprise from 10% to about 50% of the
22 dielectric layer (mole percent) before and after the exposing.

1 9
2 52 A low k interlevel dielectric layer fabrication method
comprising:

3 providing a substrate having integrated circuitry at least partially
4 formed thereon;

5 forming an interlevel dielectric layer comprising a compound having
6 silicon bonded to both nitrogen and an organic material and having a
7 dielectric constant no greater than 8.0 over said substrate; and

8 after forming the dielectric layer, exposing it to a plasma
9 comprising nitrogen effective to reduce the dielectric constant to below
10 what it was prior to said exposing.

11 210
12 53. The method of claim 52 comprising exposing the dielectric
13 layer to a plasma comprising nitrogen effective to reduce the dielectric
14 constant to at least 15% below what it was prior to said exposing.

15 311
16 54. The method of claim 52 wherein the nitrogen comprising
17 plasma is at least in part derived from N₂.

18 101
19 55. The method of claim 52 wherein the nitrogen comprising
20 plasma is at least in part derived from NH₃.

21 512
22 56. The method of claim 52 wherein the nitrogen comprising
23 plasma is at least in part derived from N₂H₄.

1 *64* 57. The method of claim *52* wherein the nitrogen comprising
2 plasma is at least in part derived from N₂O.

3 *1* *1* 58. The method of claim *52* wherein the nitrogen comprising
4 plasma is at least in part derived from NO_x.

5 *6* *Re* 59. The method of claim *52* wherein the exposing is void of
6 oxygen.

7 *9* *1* 60. The method of claim *52* wherein the dielectric layer is
8 formed by chemical vapor deposition in a chamber, the exposing
9 occurring within the chamber without removing the substrate from the
10 chamber between the forming and the exposing.

11 *14* *1* 61. The method of claim *52* wherein the plasma exposing is
12 ineffective to appreciably etch the interlevel dielectric layer.

13 *17* *1* 62. The method of claim *52* wherein a whole of the dielectric
14 layer subjected to the exposing is not transformed from one base
15 chemistry to another by the exposing.

1 *12*
2 *63.* The method of claim *52* wherein the dielectric layer
3 subjected to the exposing comprises $(CH_3)_xSi_3N_{(4-x)}$, with x being
4 greater than 0 and no greater than 4.

5 *13*
6 *64.* The method of claim *52* wherein the dielectric layer
7 subjected to the exposing consists essentially of $(CH_3)_xSi_3N_{(4-x)}$, with
8 x being greater than 0 and no greater than 4.

9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24